Enclosure 7
LDB Support Overview

1.) LDB Launch Locations: LDB missions are currently supported for launch from McMurdo, Antarctica; Fairbanks, Alaska; Alice Springs, Australia; and Kiruna, Sweden.

McMurdo, Antarctica: Launches are conducted from William's Field located about seven miles from McMurdo on the Ross Ice Shelf. Since 1996, the launch site has been operated exclusively as a field camp to support balloon operations. Launch site position is on or about 77.86 degrees South Latitude and 167.13 Degrees East Longitude near sea level. A single circumpolar flight trajectory is nominally 9 to 12 days, traveling to the west, and typically bounded between 73 to 82 degrees south latitude for balloon float altitudes of 115,000 to 130,000 feet. For mission planning purposes, logistics requirements are quite stringent; therefore, experiment, payload, and ground support equipment must be flight ready prior to departure from the United States. Logistics, housing, meals, and other on-site support is provided by NSF (National Science Foundation) who has responsibility for management of U.S. sponsored polar programs in Antarctica.

Launch operations are normally conducted from about 1 December through 10 January each year. However, due to end-of-season logistics, you should plan to be flight ready by 5 December so that your flight can be conducted with minimum risk of interfering with other NSF logistics support requirements. Approval for launch after January 1 through January 10 is with NSF concurrence and can be driven based upon other polar projects being supported. Flights may remain aloft as late as 21 January but recovery assets become scarcer near the end of the season. Experimenters hoping for two circumpolar trajectories should plan to be flight ready absolutely no later than 5 December in order to allow sufficient time to conduct an 18 to 21 day flight mission, allow for launch delays, and be accommodating within the NSF logistics support schedule for termination and recovery.

CSBF support personnel normally begin arriving at McMurdo around 1 November each year. Science personnel may arrive earlier if required to insure their flight readiness date. This scheduling will be coordinated by the CSBF Campaign Manager. Typical departure dates from Antarctica run no later than around 20th to 30th of January in order to insure complete departure of equipment and personnel before the NSF's "Winter-Over" operations begin.

Shipping of all CSBF equipment in support of each year's campaign is no later than the end of August in order to allow time for equipment to arrive at Port Hueneme, California for on-forward ocean shipment to New Zealand and then to McMurdo by air. This includes experiments, ground station equipment, flight equipment, and all final shipments required for flight support the following November. Although CSBF arranges for the shipping carrier from Palestine to Port Hueneme, experimenters are expected to provide proper shipping containers and perform their own packing prior to shipment. CSBF ships heavy items such as balloons and helium to McMurdo one year in advance so special balloon configuration requirements must be identified early enough to be built and shipped. This typically means that special balloon requirements must be identified and approved no later than the first of May for operations which require them to be used two summer seasons hence in order to allow sufficient time for special engineering considerations, construction, and shipment to Port Hueneme, California prior to on-forwarding to Antarctica.

Because shipment of equipment is due out by the end of August, pre-deployment integration at Palestine must be concluded by the middle of August each year. *Following this integration and compatibility testing, a Mission Readiness Review (MRR) is conducted prior to shipment to assess the readiness of both the experimenter and the CSBF.* Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Port Hueneme following pre-deployment integration. After pre-deployment integration, no configuration changes to the science experiment or the CSBF support systems are allowed following integration without approval from the Mission Readiness Review technical panel.

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB *Flight Application Form*.

Kiruna, Sweden: Kiruna is located about 67.86 Degrees North Latitude and 20.43 Degrees Eest Longitude. Launch operations are normally conducted between 15 May and 10 July of each year. Flight trajectory is to the west bounded between 60 degrees and 70 degrees north latitude for a 5 to 10 day mission and then terminated over Alaska or Canada. Float altitudes of 115,000 to 130,000 feet can be expected.

Pre-deployment integration at Palestine will be normally *concluded* by the first of March. *A MRR will be conducted at Palestine following integration and compatibility testing to assess readiness prior to shipping of equipment to Kiruna.* Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Kiruna following pre-deployment integration. The CSBF Campaign Manager will coordinate final shipping from Palestine to Kiruna. No configuration changes to the science experiment or the CSBF support systems are allowed following integration unless approved by the Mission Readiness Review technical panel.

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB *Flight Application Form.*

Fairbanks, Alaska: Fairbanks is located about 64.67 Degrees North Latitude and 147.07 Degrees West Longitude. Launch operations are normally conducted between 1 June and 10 July of each year. Flight trajectory is to the west with a single circumglobal route bounded between 60 degrees and 70 degrees north latitude for a 9 to 12 day mission and then terminated over Alaska or Canada. Float altitudes of 115,000 to 130,000 feet can be expected.

Pre-deployment integration at Palestine will be normally *concluded* by the first of May. *A MRR will be conducted at Palestine following integration and compatibility testing to assess readiness prior to shipping of equipment to Fairbanks.* Scheduling and special support required for the pre-deployment integration will be jointly worked out between the experimenter and CSBF once the flight request is reviewed. It should be understood that all equipment is shipped directly from the CSBF to Fairbanks following pre-deployment integration. The CSBF Campaign Manager will coordinate final shipping from Palestine to Fairbanks. No configuration changes to the science experiment or the CSBF support systems are allowed following integration unless approved by the Mission Readiness Review technical panel.

Pertinent details as to thermal environment and configuration, balloon performance, mechanical configuration, telemetry support, and ground support will be reviewed following receipt of the LDB *Flight Application Form.*

Alice Springs, Australia: As of this writing, planning and analysis is still underway for future Alice Springs LDB campaigns. Experimenters requiring an Alice Springs launch site should contact the CSBF concerning the latest planning updates.

2.) SIP (Support Instrumentation Package) Configuration: Every SIP has a similar architecture centered around a COMM1 (TDRSS) and COMM2 (IRIDIUM) flight telemetry system. Some redundancy is provided between the functions supported by COMM1 and COMM2. Each COMM system has its own flight computer which supports RS232 communications with forward and return telemetry to the science user. Each COMM system is powered from its own separate power bus (two separate PV power systems are flown for each SIP). Enclosures 8 and 9 provide information concerning the science port interfaces to COMM 1 and COMM 2. The following explanation of various subsystems is provided to assist you with planning your TM support requirements.

Experimenter's are STRONGLY encouraged to use both COMM1 and COMM2 low-rate science ports primarily for commanding redundancy. If the TDRSS link is unavailable, then the IRIDIUM link can be utilized and vice-versa. Otherwise, there will be no command path once the payload is out of line-of-sight.

IRIDIUM:

Iridium provides global forward and return telemetry with the balloon via a network of LEO satellites. Commands (forward TM) can be sent from both the OCC at Palestine and during testing from the ROCC at the launch site. Data (return TM) is received at the OCC and can be tested from the ROCC. Data is usually received within a few minutes of transmission from the balloon depending upon the load of network traffic.

Science return telemetry and forward command data is accessed via Irdium through the SIP's COMM2 science port. Science users do not have direct control over the flight Iridium terminal. All science data written to the COMM2 science port is also logged on hard disk, for the duration of the flight mission**,** which is recovered only after flight termination and physical recovery of the science payload (see enclosure 9.) Although the COMM2 science port operates at 2400 baud, bear in mind this is a packetized system and return data throughput is one 255 byte packet every 15 minutes when the flight Iridium terminal is logged into network. The latest science data packet passed along to the LDB SIP SPU prior to transmission is what gets sent. Aggregate return telemetry via COMM2 is approximately 1020 bytes of data every hour.

TDRSS:

Nominal TDRSS support for LDB offers 6 kilo-bit return telemetry continuously (the low rate science interface is also available). The SIP records all science data onto flight hard drives which are received by the SIP CPU at the rate of 6 kbps (aggregate) X 21 days. Provision can be made to recover this recorded data during playback in flight by utilizing the TDRSS SA (Single Access) mode at higher data rates. CSBF is limited to an approximately ten minute period every hour for SA support. However, playback at the lower MA (Multiple Access) rate of 3 kbps can be accomplished as well, and still maintain "real-time" return over the other channel at 3 kbps (The I & Q channels can operate as two independent 3 kb channels or as a single combined 6 kb channel only during MA services.)

The POCC (Payload Operations Control Center) located at Palestine is the only location which TDRSS science data and commanding is accessed during the flight. Support is available in the field to verify TDRSS return and forward TM using a special test set; however, this does not allow for science access to TDRSS TM and commanding other than when working around the payload in close proximity during pre-flight preparations.

Science Stack:

A science stack can be made available which provides analog and digital return telemetry and discrete command outputs. Refer to Enclosure 10 for more information. This stack is accessed by either the COMM 1 or COMM 2 telemetry links.

LOS (Line-of-Site) Return Telemetry:

An L-Band or S-Band telemetry transmitter can be made available for science use for monitoring data while within line-of-site of the launch site. Serial isolation to this transmitter is required. The experimenter is responsible for any encoding the signal may require (i.e. bi-phase, NRZ-M, etc.) as well as setting of proper signal levels into the transmitter (contact the CSBF for information concerning proper signal level settings).

LDB Ground Stations: (Refer to Enclosure 8). The ROCC (Remote Operations Control Center - launch site) and OCC (Operations Control Center - Palestine) provide similar capabilities. The *Science GSE Computer to LDB GSE Computer interface (Enclosure 8)* is the same for both the ROCC and OCC configurations. The ROCC is used at both the Antarctica and the Mid-Latitude launch sites. The ROCC is the primary CSBF Control Center during launch and after the balloon reaches float altitude and prior to it leaving the launch site TM coverage range. Operational Control is then handed over to the OCC at Palestine.

The OCC in Palestine is the only point of interface for the experimenter requiring TDRSS support. All TDRSS return telemetry and forward commanding is available only at the OCC. In addition, Iridium data and commanding is also available at the OCC. The experimenter should plan to have his/her GSE located at the OCC.

END

Enclosure 8
Science to Ground Computer Interface Specifications

Science will be interfaced to the ground control computer via two RS232-C ports. This interface provides a means of getting data to the payload and receiving data from the payload. One port will be used to send commands and the other will be used to receive data. The ground support computer will constantly monitor the science interface port for requests. **(Note: These two ports communicate at two different baud rates. See details below.)**

The ground support computer operator controls all access to all communication links. The ground support computer operator can disable access to any uplink at any time. The scientist will specify what link he or she wishes to use to transmit to the balloon. Scientists will receive an error message if their selected link is disabled. If the link is not disabled, and a request-to-send packet is received from science, the data will be repacketized and sent through desired link consisting of LOS, COMM 1 or COMM 2.

PHYSICAL INTERFACE:

<u>Downlink (return TM) Port:</u> 19,200 Baud, 8 data bits, 1 stop bit, no parity std. RS232-C DB25 DTE.

<u>Command Uplink Port:</u> 2400 Baud, 8 data bits, 1 stop bit, no parity std. RS232-C DB25 DTE.

(Note: This interface does not utilize CTS or DTR. It is 3 - wires using only Tx, Rx, and GND...no hardware handshaking.)

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COMMAND UPLINK:

In Byte 4, you specify the number of byes following (up to 20) which you are sending as command data starting at byte 5.

<u>Required Formats of Request-to-Send Packets</u>

Byte 1:	Start Byte: ascii.dle (ascii.dle = 10_H)
Byte 2:	Link Routing: 0,1,2
Byte 3:	Routing address: 9,C
Byte 4:	Length: up to 20, must be a multiple of 2
Byte 5-?:	Data: even number of bytes up to 20 k
Byte ?+1:	Stop Byte: ascii.etx (ascii.etx = 3_H)

<u>Byte 2 specifies the link routing as follows</u>:

0_H Selects LOS as the Link
1_H Selects COMM 1 (TDRSS) as the Link
2_H Selects COMM 2 (IRIDIUM) as the Link

<u>Byte 3 specifies the routing address:</u>

9_H Selects Science Interface COMM 1
C_H Selects Science Interface COMM 2

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Valid Combinations of Bytes 2 and 3 of the Request to Send Packet

BYTE 2 (Link Selection)	BYTE 3 (Routing Address)
0 (LOS)	9_H=COMM 1 or C_H=COMM 2
1 (COMM 1)	9
2 (COMM 2)	C

The experimenter doesn't have to worry about the balloon number. The LDB GSE handles this automatically.

The following example illustrates how the science input is interpreted:

Example: Suppose the science request packet is:

Byte 1: ascii.dle
Byte 2: 0

Byte 3: 9
Byte 4: 4
Byte 5-8: 9, A, B, C
Byte 9: ascii.etx

Assuming the balloon number is 0 then, the following two LDB packets will be sent via the LOS command link to COMM 1:

Packet 1: FA F3 09 F6 09 F6 0A F5
Packet 2: FA F3 09 F6 0B F4 0C F3

Eight Byte Command Binary Format

Byte Number	Value Binary	Hex	Description
0	11111010	FA	Sync Word 1
1	11110011	F3	Sync Word 2
2	**BBBB***RRRR*	??	**Balloon**/*Routing* Address
3	????????	??	One's Complement byte 2
4	XXXXXXXX	??	AART Address or Science command byte 1 or Flight CPU command byte 1
5	????????	??	One's complement byte 4
6	XXXXXXXX	??	Command select or Science command byte 2 or Flight CPU command byte 2
7	????????	??	One’s complement of byte 6

Experimenter data is contained in bytes 4 and 6 in each of above packets. Experimenter commands off the SIP’s science port is defined in Enclosure 9 under ID Byte 14_H. The above example is given only to illustrate how the physical transmission is made going to the SIP.

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Data Addressed to Comm Science Command Interface Port (Routing Address 9_H and C_H)

On the ground, science command data will be repacketized two bytes at a time. Once received on board, the data will be repacketized by the LDB flight computer and will be sent to the onboard science interface port (two bytes at a time) in the format specified by the "Science to Flight Computer Interface Specifications" (see Enclosure 9).

Accessing the Science Discrete Command Deck

Science can access the science discrete command deck directly through a web interface. A description of the capabilities of the Science Discrete command deck is given in Enclosure 10.

Acknowledgment Packet Format

In all cases after a packet is received by the ground support computer, an acknowledgment packet will be sent to science to indicate whether or not the commands were transmitted.

Byte 1: Sync byte 1 = FA_H
Byte 2: Sync byte 2 = $F3_H$
Byte 3: Acknowledgment Byte = 00_H
or = $0A_H$
or = $0B_H$
or = $0C_H$
(00_H, commands transmitted)
($0A_H$, $0B_H$, $0C_H$, $0D_H$ commands not transmitted)

An acknowledgment byte of hex A, B, or C indicates that the ground support computer did not send the command packet. Any of the following can cause this to occur:

ERROR CODES:

$0A_H$> GSE operator disabled science from sending commands,
$0B_H$> Routing address does not match the selected link,
$0C_H$> The link selected was not enabled,
$0D_H$> All other cases.

An acknowledgment byte of 00_H indicates that the commands were sent. This does not mean that the science payload received the commands. Science must monitor their own telemetry data to determine whether or not their equipment received and responded to their commands. All command packets received by the ground support computer will be time-tagged and logged along with their transmission status. NOTE: It is possible that if more than two bytes are sent, the payload (SIP) may not receive them all in rare cases of dropouts in a particular RF link.

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DOWNLINK

Science telemetry data will be time-tagged and logged, repacketized and sent to science via the science telemetry interface port. The following summarizes the various packet formats in which science telemetry data will be sent to science.

A. RESERVED

Byte 1: Sync 1 = FA_H
Byte 2: Sync 2 = FC_H
Byte 3: Origin byte
- Lower nibble:
  - bits 0 .. 2: (0_H-Science Housekeeping Deck or 1_H-Low Rate Science Port)
  - bit 3: (0_H-COMM1 or 1_H-COMM2)
- Upper nibble: is zeroed out by LDB computer

Byte 4: 0 (not used, zero inserted)
Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N: Data (1..length)
Byte N+1: Checksum (Σ bytes 3-N)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

B. IRIDIUM

Byte 1: Sync 1 = FA_H
Byte 2: Sync 2 = FD_H
Byte 3: Origin byte
- Lower nibble:
  - bits 0 .. 2: (0_H-Science Housekeeping Deck or 1_H-Low Rate Science Port, 2_H-High Rate Science Port)
  - bit 3: (0_H-COMM1 or 1_H-COMM2)
- Upper nibble: is zeroed out by LDB computer

Byte 4: 0 (not used, zero inserted)
Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N: Data (1..length)
Byte N+1: Checksum (Σ bytes 3-N)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

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C. TDRSS

Byte 1: Sync 1 = FA_H
Byte 2: Sync 2 = FF_H
Byte 3: Origin byte
Lower nibble:
bits 0 .. 2: (0_H-Housekeeping Deck, 1_H-Low Rate Science Port, 2_H-High Rate Science Port)
bit 3: (0_H-COMM1 or 1_H-COMM2)
Upper nibble: is zeroed out by LDB computer
Byte 4: 0 (not used, zero inserted)
Byte 5: Length of data (MSB)
Byte 6: Length of data (LSB)
Byte 7-N: Data (1..length)
Byte N+1: Checksum (Σ bytes 3-?)

Bytes 5 and 6 tell how many bytes follow from Byte 7 to Byte 7+N.

D. RESERVED

Byte 1: Sync 1 = FA_H
Byte 2: Sync 2 = FE_H
Bytes 3-34: Data (32 bytes)

END

Enclosure 9
Science to Flight Computer Interface Specifications

I. Science Comm Port

This document describes the interface to the low rate and high rate science interfaces. A low rate science support interface (RS232) is available on each Communication Link computer (COMM1 and COMM2) simultaneously. Either of these serial lines can handle low rate science data to be included in the downlink, uplink commands addressed to the science experiment, and SIP data (GPS position, GPS time, and MKS pressure if requested by the science.) Data sent by the science to the two communications link need not be the same, if the science chooses increased data downlink over redundancy. The high rate science support interface (RS232) is available only from the SIP's TDRSS communication link.

Physical Interface

Low Rate Science Interface

1200 baud, 8 data bits, 1 stop bit, no parity
standard RS232-C DB9 DTE

(Note: This interface does not utilize CTS or DTR. It is 3 - wires using only Tx, Rx, and GND...no hardware handshaking.)

High Rate Science Interface

19,200 baud, 8 data bits, 1 stop bit, no parity
standard RS232-C DB9 DTE

(Note: This interface does not utilize CTS or DTR. It is 3 - wires using only Tx, Rx, and GND...no hardware handshaking.)

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Software Interface

Low Rate Science Interface

Because the Low Rate Science Interface is a more complicated interface, it will be implemented using a message protocol. The format of a message is

ascii.dle, ID Byte, optional data bytes, ascii.etx

(ascii.dle = 10_H and ascii.etx = 3_H)

The message protocol will follow in more detail.

High Rate Science Interface

The High Rate Science Interface will log and transmit all data presented to it. There is no format requirement like that required for the Low Rate port (i.e. ascii.dle, ascii.etx, etc.) Whatever is presented to the High Rate Port is what gets logged and transmitted. The Science must ensure that the average bit rate to the High Rate Science Interface is not greater than 6Kbit/Second. (If requesting dual channel mode, then must be able to switch to 3 Kbit/Second. See Enclosure 7, page 4, under TDRSS.) Note of Caution: no error checking or synchronization will be provided. The system will log what is received. Experimenters need to do their own encoding to provide for the above operations.

Low Rate Science Interface Messages From LDB COMM CPU to Science:

GPS position (ID byte = 10_H)

The format of the GPS position message is

ascii.dle, 10_H, longitude, latitude, altitude, satellite status1, satellite status2 ascii.etx

Where longitude, latitude, and altitude are 4 byte ***IEEE std 754*** single precision real format numbers. Longitude and latitude are in degrees. Altitude is in meters. Satellite status1 & satellite2 are bytes.

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An example of a real number will be generated to show the byte order.

LSB			MSB		
109	120	238	191	=	-1.86305E00

LSB (109) is sent first and MSB (191) is sent last.

The bytes are packed to form a single precision real format number as follows:

	MSB				LSB
1	0 1 1 1 1 1 1 1	1 1 0 1 1 1 0	0 1 1 1 1 0 0 0	0 1 1 0 1 1 0 1	
A	B	C			

A: Sign bit, 1=negative 0=positive

B: Exponent, Represented using Excess Notation;
(8 bit represented above) - 127 = Actual Exponent

i.e. 01111111 (127) - 127 = 0;
10000000 (128) - 127 = 1;
10000001 (129) - 127 = 2, etc.

C: Mantissa, Only the fractional part of the mantissa is given above.
All data is *normalized with the "Phantom Bit"* 1 as *given.*

$\Sigma 2^{(-N)}$ = Fractional mantissa

Where N = 1,2,4,5,6,9,10,11,12,17,18,20,21,23 for above example reading the bits from left to right under part C.

$\therefore$ (Phantom Bit).(Fractional Mantissa) X 2^0 = -1.86305E00

If exponent had been E02, then:
(Phantom Bit).(Fractional Mantissa) X 2^2 = -7.4522

A zero exponent combined with a zero mantissa represents zero: *if the mantissa is nonzero, it is taken as a non-normalized number.*

Sign notation is negative for west longitudes and south latitudes.

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Satellite status1	=	3_H => 3 sat, 2D
		4_H => 4 sat, 3D
Satellite status2	=	0_H => Doing position fixes
	=	1_H => Do not have GPS time
	=	2_H => Waiting for almanac collection
	=	3_H => PDOP is too high
	=	4_H => 0 satellites
	=	5_H => 1 satellite
	=	6_H => 2 satellites
	=	7_H => 3 satellites
	=	8_H => 0 usable satellites
	=	9_H => 1 usable satellite
	=	A_H => 2 usable satellites
	=	B_H => 3 usable satellites

NOTE: For the GPS to be giving current information Satellite status1 must be 3 or 4 and satellite status2 must be 0.

GPS time (ID byte = 11_H)

The format of the GPS time is

ascii.dle, 11_H, GPS time of week, GPS week number, GPS/UTC time offset, CPU time, ascii.etx

where GPS time of week represents the number of seconds since Sunday at 12:00 AM. The GPS week number is referenced from week #1 starting January 6, 1980. GPS/UTC time offset should be subtracted from the GPS time to obtain UTC time. If GPS time of week is < 0 then the current GPS time is not known. The GPS time is updated in the LDB COMM CPU every 15 seconds when the GPS receiver is not doing position fixes and every 150 seconds when the GPS receiver is doing position fixes (this is a function of the GPS receiver itself). GPS time of week and GPS/UTC offset are 4 byte real numbers. GPS week number is a 2 byte integer. CPU time is seconds from midnight today synchronized to GPS time when status1 > 3, status2 is 0, and CPU time is more than 60 seconds off.

NOTE: This time should not be used for exact timekeeping purposes.

MKS pressure altitude (ID byte = 12_H)

The format of the MKS pressure altitude message is:

ascii.dle, 12_H, MKS Hi, MKS Mid, MKS Lo, ascii.etx

MKS pressure altitude is two bytes where the MSB is transmitted first.
The LDB Payload Engineer will provide, upon request, the switch points to be used so you will know which sensor (Hi, Mid, or Lo) to use while in its “active” linear range. MKS sensors are defined here as:

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MKS Hi	=	high altitude sensor (0 to 10 torr)
MKS Mid	=	mid altitude sensor (0 to 100 torr)
MKS Lo	=	low altitude sensor (0 to 1000 torr)

MKS Algorithms

MKS pressure is derived from a linear equation of the type y=mx + b (where x=number of counts given in each two byte packet and y=pressure in millibars. You will need to get the m and b variables for this equation from the LDB Payload Engineer as it is dependent upon each set of sensors and their calibration coefficients. Pressure Altitude is expressed in terms of Standard Atmosphere.

Let Z = Natural Log (pressure)

$$\text{Altitude in feet} = 156776.89 + -25410.089 * Z + 462.44626 * Z^2 + 130.61746 * Z^3 + -20.0116288 * Z^4$$

Request Science Data (ID byte = 13_H)

The format of the Request Science log data is:

ascii.dle, 13_H, ascii.etx

This message informs the science interface that the LDB COMM computer is ready to accept a message packet from the Science Interface. The COMM computer will repeat this message at science transmissions opportunities when its LDB science buffer is empty (the most recent science data passed over to the LDB flight computer is what gets transmitted when the LDB science buffer is empty); however, all science data requested by the LDB flight computer is logged onto the LDB hard disk drive whether it gets transmitted or not. Presently, the LDB flight computer polls the science port for new data every 30 seconds.

Science Command (ID byte = 14_H)

The format of the Science Command message is

ascii.dle, 14_H, length (always 2), data, ascii.etx

The message relays data addressed to the science package from the GSE systems. The *length* is the number of bytes of data passed to the science which is always two based on the LDB command format. If more than two bytes were sent from the GSE, then it is possible that some bytes do not pass error checking and therefore

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are not passed to the science interface. The *data* is the data bytes passed to the science.

Eight Byte Command Binary Format

Byte Number	Value Binary	Hex	Description
0	11111010	FA	Sync Word 1
1	11110011	F3	Sync Word 2
2	**BBBB***RRRR*	??	**Balloon**/*Routing* Address
3	????????	??	One's Complement byte 2
4	XXXXXXXX	??	AART Address or Science command byte 1 or Flight CPU command byte 1
5	????????	??	One's complement byte 4
6	XXXXXXXX	??	Command select or Science command byte 2 or Flight CPU command byte 2
7	????????	??	One's complement of byte 6

Science Message to the LDB COMM Computer:

Request GPS position (ID byte = 50_H)

The format of this message is

ascii.dle, 50_H, ascii.etx

This message request the LDB COMM computer to send a GPS position message.

Request GPS time (ID byte = 51_H)

The format of Request GPS time message is

ascii.dle, 51_H, ascii.etx

This message request the LDB COMM computer to send a GPS time message.

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Request MKS Altitude message (ID byte = 52_H)

The format of the Request MKS Altitude message is

ascii.dle, 52_H, ascii.etx

This message request the LDB COMM computer to send a MKS Altitude message.

Science Data Message (ID Byte = 53_H)

The format of Science Data Message is
ascii.dle, 53_H, data length, data, ascii.etx

This message contains the data which the LDB COMM computer is to transmit to the ground and log in the low rate science data log. This message must be in response to a Request Science Data message. Data length is a byte whose value must be between 1 and 255. Data is length bytes of data which will be transmitted and stored on board.

Low Rate Science Interface Messages (Examples)

Message Initiated from Science Computer		Response from LDB Comm Computer
Request GPS Position (50h)	→	GPS Position (10h)
Request GPS Time (51h)	→	GPS Time (11h)
Request MKS Altitude (52h)	→	MKS Altitude (12h)

Message Initiated from LDB Comm Computer		Response from Science Computer
Request Science Data (13h) [every 30 seconds]	→	Science Data Message (53h) [Optional Response]
Science Command (14h)	→	No Response Requried

END

Enclosure 10
Science Stack

A *Science Stack* option is available which provides:

- 32 analog channels return TM (12 bit resolution)
- 16 digital channels return TM
- 28 Open-Collector Command Outputs (200 ma maximum @ 50 volts @ 100 milli-seconds).
- 4 optional diode clamp command returns to be used if suppression diode is not available on science relay operating on Open Collector Outputs.)
- 1 Timed Open Collector Command Output (200 ma maximum @ 50 volts)
- 5 Volt Reference

One Science Stack provides the above listed functions which can be accessed by either COMM1 or COMM2. Normally, the Science Stack is an option used by those experimenters with simple telemetry support requirements and who do not wish to incorporate their own flight data and command processing computer with which to integrate to the COMM science interfaces. The science stack can also be used for redundant commanding and/or housekeeping in addition to the COMM science interfaces.

The science stack is interrogated by the LDB flight computers (COMM1 or COMM2) and return telemetry is brought down on the selected COMM link (configured before launch and is typically the link which offers the highest data rate or best command link, but is selectable). Commands from the respective COMM system are routed accordingly to the Science Stack upon recognition of the proper stack address and command decode for the individual open collector outputs. This is all managed by the LDB system and the Experimenter only has to be concerned with proper hardware integration to the Science Stack. (Please reference Appendix-B, Science to GSE Computer Interface Specifications.)

See Enclosure 9, p.7, “Science Data Message”, same limitations apply to only the first 29 bytes of a maximum 255 byte “return” packet can be transmitted via Argos.

continued...

The Science Stack is comprised of the following science decks:

1.) Science Discrete Command Deck

The hex addresses for enabling the 28 commands are as follows:

OUTPUT	HEX ADDRESS	OUTPUT	HEX ADDRESS
OUTPUT 1	09	OUTPUT 15	21
OUTPUT 2	0A	OUTPUT 16	22
OUTPUT 3	0B	OUTPUT 17	23
OUTPUT 4	0C	OUTPUT 18	24
OUTPUT 5	0D	OUTPUT 19	25
OUTPUT 6	0E	OUTPUT 20	26
OUTPUT 7	0F	OUTPUT 21	27
OUTPUT 8	11	OUTPUT 22	41
OUTPUT 9	12	OUTPUT 23	42
OUTPUT 10	13	OUTPUT 24	43
OUTPUT 11	14	OUTPUT 25	44
OUTPUT 12	15	OUTPUT 26	45
OUTPUT 13	16	OUTPUT 27	46
OUTPUT 14	17	OUTPUT 28	47

Physical Interface: DB 37P Connector (You provide 37S)

Pins	Description
1 Thru 28	Outputs 1 Thru 28
29	Clamp (not used if transient suppressor diode is on relay)
30	Digital Ground
31	Clamp (not used if transient suppressor diode is on relay)
32	Digital Ground
33	Clamp (not used if transient suppressor diode is on relay)
34	Digital Ground
35	Clamp (not used if transient suppressor diode is on relay)
36	Digital Ground

2.) Science Timed Command Outputs:

Physical Interface: DB 9P connector (You provide 9S)

Pins	Description
1	Ground
2	Output

continued...

3.) Housekeeping Deck (Return TM):

Analog Return TM Physical Interface: DB 37P Connector (You Provide 37S)

Pins	Description
1 Thru 32	Analog Inputs (0 to 5 Vdc) 12 bit resolution
33 Thru 36	Analog Grounds (signal return)
37	5 Volt Reference (buffered through LT 1078)

Digital Return TM Physical Interface: DB 35 P Connector (You Provide 25S)

Pins	Description
1 Thru 16	Digital Inputs (Input on 74HC375 - threshold is 1.5 vdc.)
18 Thru 20	Digital Grounds (signal return)
21 Thru 25	Unused

4.) Physical and Power Interface Specifications:

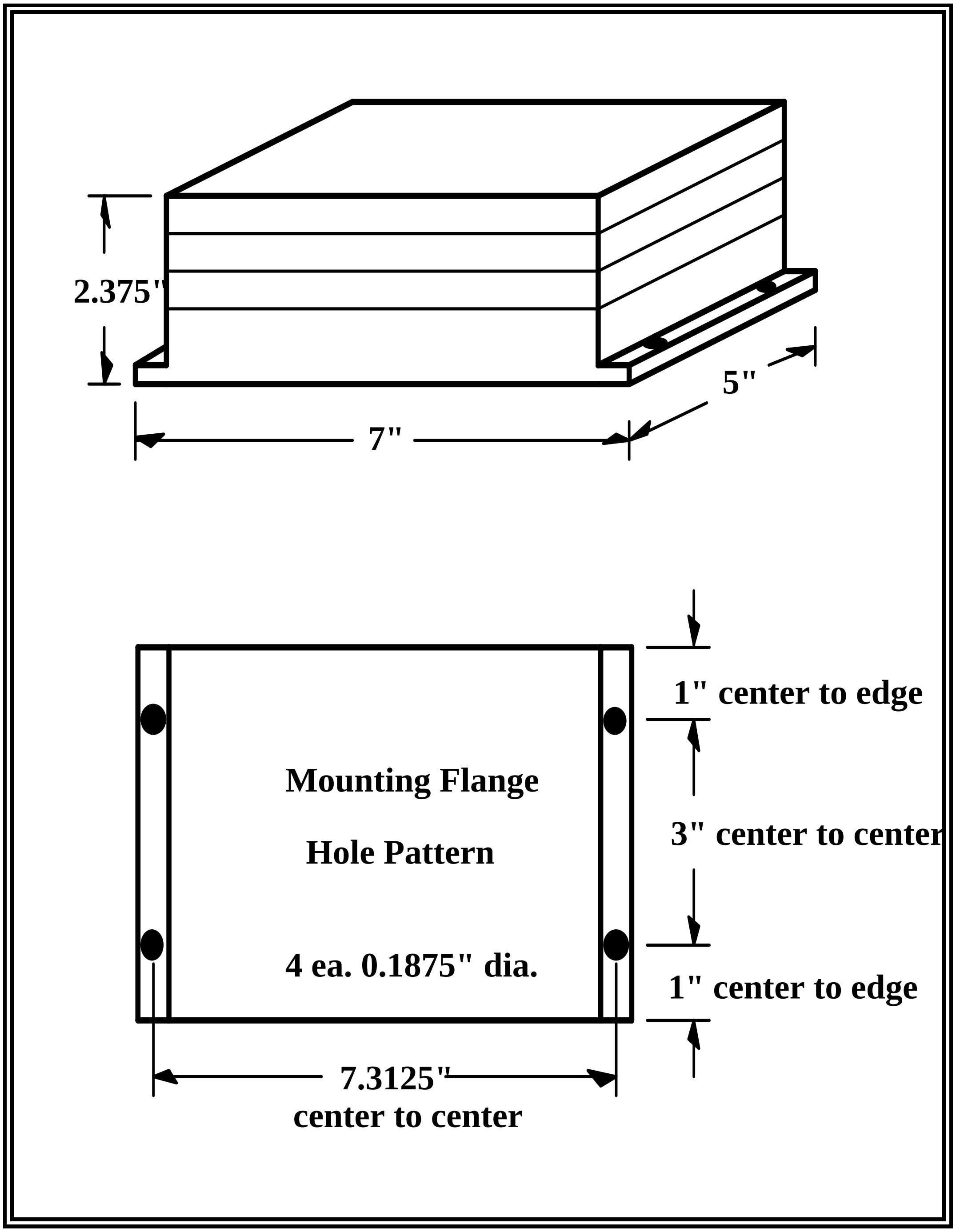
The experimenter is responsible for accommodation of mounting the Science Stack as well as providing power to the Stack. The Science Stack is serially isolated from the SIP via serial isolator built into the Stack's Power Deck. CSBF will provide the cable going from the SIP to the Science Stack.

Power: Provide 16 - 32 vdc at 50 ma (maximum current.)

Pin 1 – Power
Pin 6 – Ground

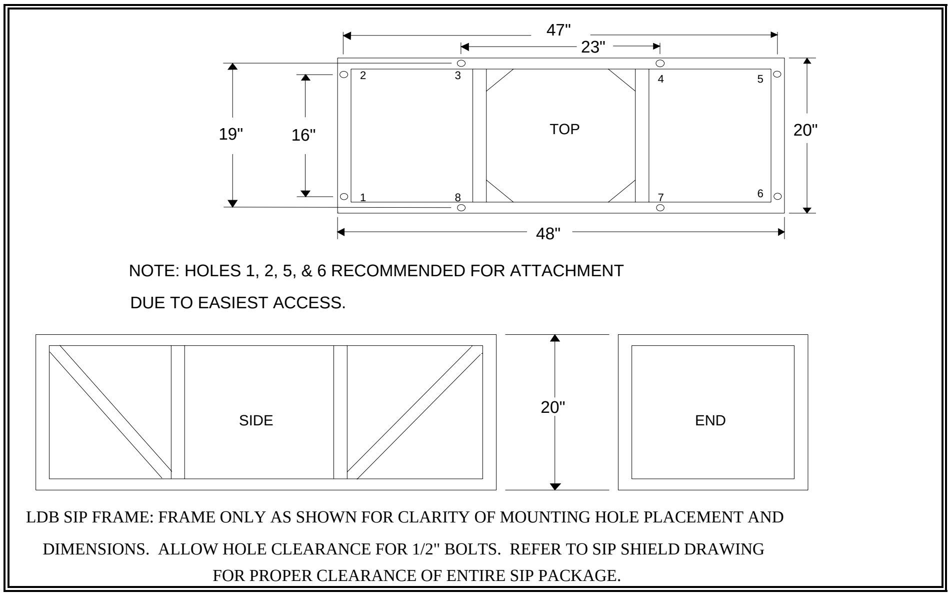
Mounting: (following page)

continued...


2.375"
5"
7"
1" center to edge
Mounting Flange
Hole Pattern
3" center to center
4 ea. 0.1875" dia.
1" center to edge
7.3125"
center to center

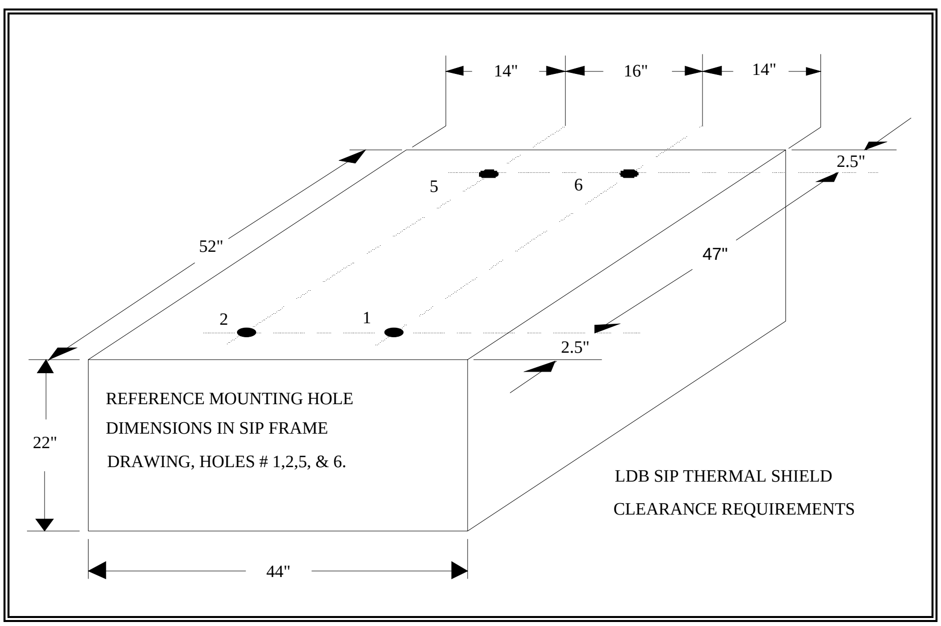
END

Enclosure 11
Mechanical



SIP Mounting Requirements:

The SIP is normally mounted by the top four outside mounting holes having 17/32 clearance. For most gondolas, this has been accomplished by suspending the SIP from the gondola structure. Electrical and thermal isolation between the SIP and SIP Thermal Shield is required with respect to the gondola. Normally, holes # 1, #2, #5, and #6 are used for mounting the SIP to the gondola.



Clearance must be provided to accommodate the SIP Thermal Shield as shown here (an additional 3 inches on the top side as well). Access to all four sides after mounting to the gondola is an absolute requirement. The SIP Thermal Shield must not be blocked by any structure on any of the four sides in order to facilitate heat transfer away from the SIP. Deviations from this configuration will be handled on a case-by-case basis. Be sure to contact the CSBF LDB Group Supervisor concerning any unique mounting requirements other than that discussed here.

Normally, CSBF will attach ballast onto the gondola structure, not the SIP frame. Again, special cases where you may require having the SIP "sit" on a gondola frame or shelf will have to be given special consideration.

LDB Weights:

The following weights are provided for estimating total gondola weights, stress analysis, etc. These weights will vary depending upon specific upper antenna boom requirements, PV array size requirements, antenna cable lengths, etc.

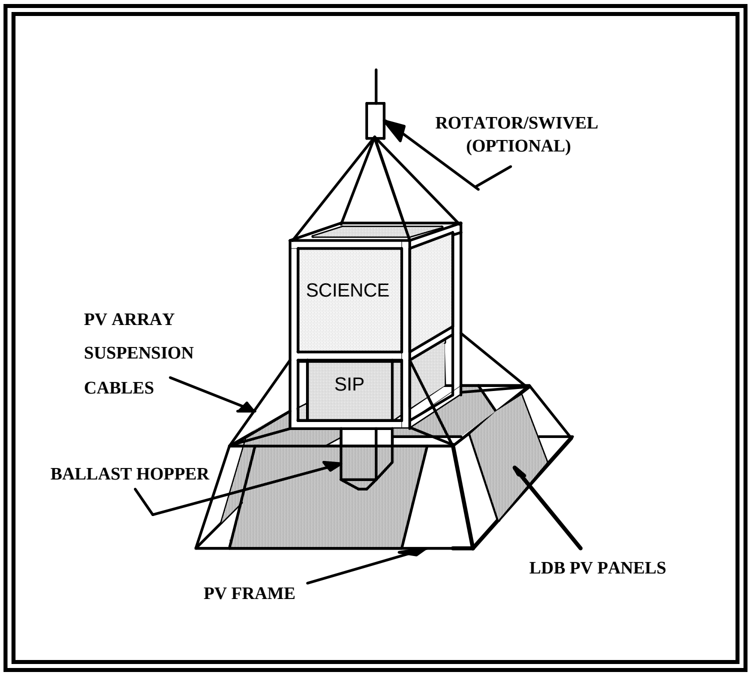
-Sip and Thermal Shield	**380 lbs.**
-Ballast Hopper / Load Cell / Ballast Valves	**23 lbs.**
-LDB Solar Array	**130 lbs.**
-PV Panels	
-Support Frame	
-Various Sensors & Antennas	
-Upper Antenna Boom / Antennas / Cabling	**40 lbs.**

Gondola Configuration:

A simplified block diagram view as shown here illustrates a typical configuration (excluding science PV array.) The SIP and suspended LDB PV array is thermally and electrically isolated from the science gondola frame.

The optional rotator or free swivel must include electrical slip rings to accommodate the SIP's serial communications lines going to the Terminate Electronics package. Eight slip rings are required but it is recommended that spares be included.

The LDB PV array is normally a four sided array even with rotators being flown in order to assure operation in the event of rotator failure. Special configurations which differ from the basic concept shown above require consultation with the CSBF prior to completing the final configuration definition. Factors influencing LDB PV Array size include gondola height, Science PV Array structure, and other factors impacting shading on the PV Array. No shading of the PV array is allowed for any angle of the gondola with respect to the sun at any elevation. Other factors impacting placement of all PV (science and LDB) panels includes thermal consideration such that no vulnerable components are placed directly to the backside of a PV panel.



Antennas:

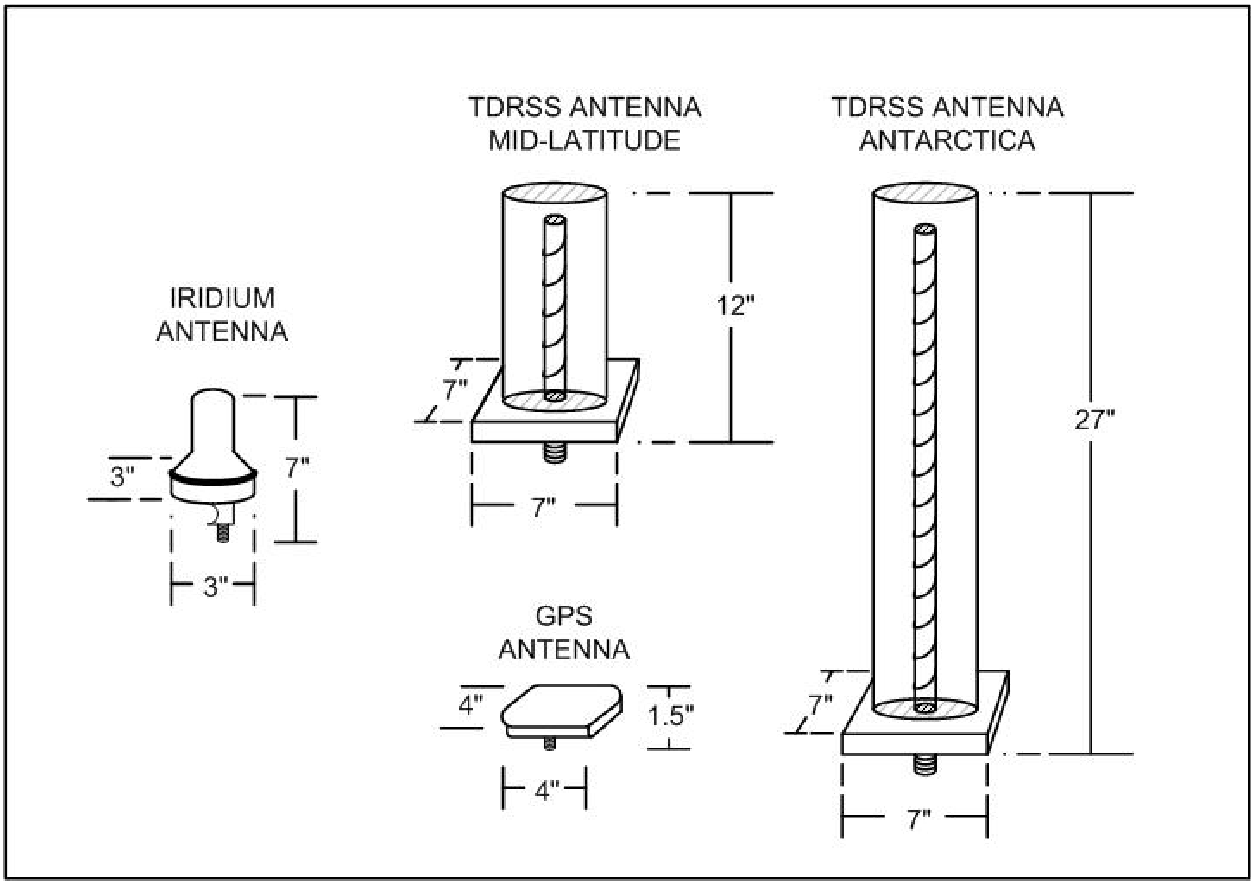
LDB flies a number of antennas which must be mounted on top the gondola with minimum obscuration horizon to horizon for 360 degrees about each antenna. Obviously, gondola suspension members will provide some obscuration; however, from experience this has been of little negative impact when the antennas are placed properly. Orientation of these top mounted antennas may require judicious placement depending upon pointing requirements of any given experiment. A rule-of-thumb is to insure that placement is such so as to maximize visibility of the Iridium and TDRSS antennas to any point on the geostationary orbiting satellite arc as seen from the balloon. The GPS antennas must view polar orbiting satellites.

Antenna dimensions are as shown below. Other antennas for line-of-sight forward and return communications are mounted on the bottom of the LDB Solar array. If you don't provide a location for placement of the top antennas, CSBF will provide a boom attached to your gondola to mount these antennas on. Antennas are electrically isolated from the gondola.

The number of antennas mounted at the top are:

> **TDRSS-1 (mid-latitude or Antarctica)**
> **Iridium-2**
> **GPS-3**

ANTENNA	LOCATION	FUNCTION	FREQ (MHZ)	EIRP	TYPE	CABLE	CONNECTOR TYPE
IRIDIUM	TOP	CMD/TM	TX/RX 1616.5 TO 1625.5	0.57 Watts	OMNI RHCP	RG214	TNC-FEMALE
TDRSS	TOP	CMD/TM	2106.5 (Rx) 2287.5 (Tx)	9 dbW Peak	OMNI LHCP	RIGID COAX	TNC-FEMALE
GPS	TOP	RX / NAV	1575.42	N/A	RHCP	RG223	SMA
L-BAND	BOTTOM	TX/LOS TM	1444.5-1525.5	2 WATT	1/4VERT.	RG214	N-FEMALE
S-BAND	BOTTOM	TX/LOS TM	2378.5-2387.5	5 WATT	1/4 VERT.	RG214	N-FEMALE
UHF	BOTTOM	RX/LOS CMD	429.5	N/A	1/4 VERT.	RG223	BNC



Thermal:

A thermal analysis is required for each LDB science payload. This analysis must be completed sufficiently in advance of final integration at Palestine to insure proper configurations are made prior to shipment to the field.

LDB Project Thermal Analysis support is provided only for CSBF's equipment and systems. Experimenters need to have their own thermal analysis support in order to calculate their operating parameters within the chosen environment. Environmental flight conditions differ between Antarctica flights and Mid-Latitude flights.

The LDB Project's Thermal Analyst will work with the Experimenter's Thermal Analyst to resolve intra system thermal coupling issues, etc. Due to the length of time to perform this analysis, it is important to establish the gondola configuration and mounting location for the SIP, solar arrays, and instruments as soon as possible. Results of the thermal analysis can result in change of requirements for mounting locations and/or component surface coatings, thermal shields, etc.

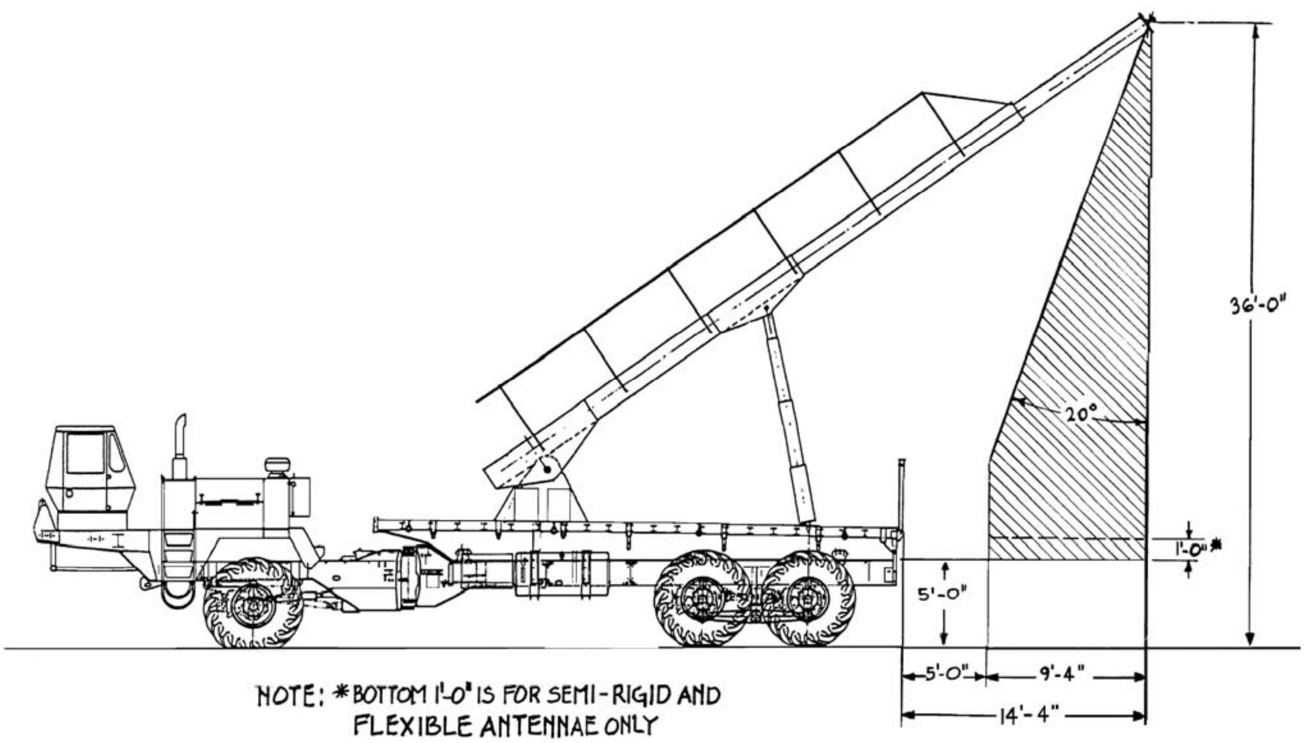
Launch Vehicle Requirements in Antarctica:

1.) The height of the payload suspension point on the launch vehicle is fixed at 36 feet above the ground surface.

2.) A minimum ground clearance of 5 feet between the ground surface and the lowest point of the LDB payload is required.

3.) The combined height of the LDB Support Instrumentation Package (SIP) and the LDB omnidirectional solar panel array is approximately 6 feet. The SIP has been shown in the diagram mounted externally at the base of the science gondola. Other mounting configurations for the SIP may be possible.

4.) The dashed line, marked “A”, describes a plane which delimits acceptable and unacceptable payload geometry. Experience has shown that any payload element which extends above and to the right of this dashed line will strike the underside of the boom during the launch.



Recovery Requirements:

Antarctica - From a science, economical, and environmental standpoint, it is highly desirable to recover 100% of the payload. To date only one gondola has been recovered utilizing the LC-130 aircraft. This is largely due to accessibility of the aircraft (the LC-130) and surface conditions at or near the impact site.

Most recoveries are done with a Twin Otter or Helicopter. Making use of the Twin Otter, each discipline must be aware of the usable space and configuration with this aircraft. The cargo door opening of the Twin Otter is: 56.0" wide X 50.0" high. Two hundred pounds per square foot is the limitation of the cargo density. Because the Twin Otter cargo holding area tapers from fore to aft and because of other operations considerations, final coordination of your recovery package dimensions must be coordinated with the CSBF Campaign Manager. The Twin Otter can usually get off the snow surface with 2,200 lbs. on board. This capacity diminishes with altitude and poor surface conditions.

The helicopters have a very limited inside cargo carrying capacity and can sling loads up to 1,800 lbs. As you can see by the above dimensions, several trips are required for a complete recovery. With this information, each science group should be building payloads such that they will break down into components that will fit in the Twin Otter or helicopter. Weights are manageable by a limited ground crew. Various components must withstand extended periods of time exposed on the Antarctic surface waiting for a recovery to take place. ***Payloads built with a single source recovery aircraft in mind, IE. LC-130 Hercules, run the risk of not getting their payload recovered.***

Greenland - For Fairbanks back to Canada trajectories, termination and recovery from Greenland is now planned only as a contingency in the event of an emergency. CSBF currently plans on utilizing its own aircraft for the terminate portion of the operations. LC-130's operated by the New York Air National Guard (NYANG) might be available for recovery. Other options for recovery do exist but at high cost. There are ski-equipped Twin Otters available in Canada and Iceland, but again are quite expensive to use for recovery. CSBF will be making use of the NYANG while they are positioned in Thule, Greenland supporting other NSF and military missions. This means that if a recovery opportunity is missed while they (NYANG) are positioned in Greenland, the payload would need to rest on the ice sheet until they return to Greenland or until other arrangements can be made. Again, final coordination for recovery requirements will be made with the CSBF Campaign Manager.

Fairbanks, Alice Springs, and Kiruna - Normally, recovery for “mid latitude” type launches will be handled in much the same manner as currently done for conventional ballooning. Various helicopter and ground recovery assets will be used. Gondola design should take into account ease of recovery in remote locations which often require helicopter lifts.

END